MEMORANDUM

November 21, 2004

FOR: FCRPS Remand File

FROM: Chris Toole

SUBJECT: Sensitivity to Snake River Fall Chinook D-Values for Estimating Survival Rate Estimates in the FCRPS Biological Opinion

Background

SIMPAS simultaneously analyzes various transportation options (e.g., transport from 0-4 collector projects) for a given set of river conditions and dam operations. Because we are uncertain of the relative post-Bonneville survival ("D") of transported, compared to non-transported, Snake River (SR) fall chinook, the September 9, 2004 draft Biological Opinion (Opinion) only reported the survival rate of non-transported Snake River (SR) fall chinook salmon. This survival rate was calculated as in-river survival without transportation (i.e., SIMPAS results for transport from 0 collector projects). This is not the proposed action, but it was considered a useful surrogate because of uncertainty about transport survival. It applies to only a small proportion of the SR fall chinook juveniles arriving at LGR pool under a transport operation, as in both the proposed and reference operations.

In the narrative of Section 6.4.1.2.1, the September 9 draft Opinion stated that there is no difference in survival between the proposed and reference operations for about half of the juveniles in the ESU because: (1) those fish end up on barges; and (2) there is no difference between the reference and proposed operations with respect to transportation. The average proportion of fish on barges was virtually identical for the reference and proposed operations. In the September 9th draft, we implicitly applied the following approach to determining the proportional (relative) hydro survival "gap"[1] that would need to be offset by a similar proportional survival change in another life stage:

Hydro Survival "Gap" in Sept. 9 draft Opinion =
(50% of migrants * in-river survival "gap") + (50% of migrants * 0% transport "gap")

In a November 1, 2004 Federal review draft, we further refined this calculation using the calculated average proportions of fish placed on barges (45%) and not placed on barges (55%) to explicitly calculate the "gap" for all migrants, using the formula above.

[1] Proportional, or relative, difference between the proposed and reference operation =
(proposed survival - reference survival) ÷ reference survival. This is also referred to as the survival "gap" associated with the proposed action.

Since that draft was produced, questions have been raised regarding whether the proportions described above are the correct proportions for weighting the in-river survival gap. The concern is that the in-river survival "gap" likely applies to a much smaller than 45% proportion of the population, because the primary differences between the two operations are in the lower Columbia River, where few in-river fish remain under a transportation operation.

<u>Fate of Juveniles Arriving at the Head of LGR Reservoir - Transport Analysis</u>

To address these questions, it is helpful to look at SIMPAS results to track the fate of all juveniles arriving at the head of Lower Granite (LGR) pool until they reach the tailrace of Bonneville Dam (BON). To facilitate this tracking, the proportions of fish estimated by SIMPAS, when transportation is included in the operation, are multiplied by 1000 (Figure 1). Using output from the October 27, 2004 SIMPAS analysis of the reference operation, with transportation from four collector projects, under 1995 water conditions, we estimate that:

> 1000 fish start at the head of LGR pool
> 556 fish are placed on barges
> 444 fish are not placed on barges and either migrate or die in-river
> 11.4 fish are alive in-river in the MCN dam tailrace (below last transport site)
> 5.2 fish are alive below BON dam after migrating entirely in-river
> 545 fish are alive when released from barges below BON dam
> 550 total fish are alive immediately below BON

When looked at this in terms of mortality:

> 11 fish die on barges (556 on barges - 545 released from barges)
> 439 fish die at various locations in the river (1000 - [556 on barges + 5.2 alive at BON])

The cumulative survival rate of combined transported and non-transported fish to below Bonneville is 55%. The cumulative survival rate of the 444 non-transported fish is 1.2% (5.2 ÷ 444). Note that this characterization does not consider any mortality caused by the hydro system that is expressed below Bonneville Dam. That subject is discussed below.

<u>Fate of Juveniles Arriving at the Head of LGR Reservoir - Non-transport Analysis</u>

The analysis presented in the September 9th draft Opinion assumed that no fish were placed on barges at the four collector projects. Using output from the same October 27, 2004 SIMPAS analysis of the reference operation, without transportation from collector projects, under 1995 water conditions, we estimate that:

> 1000 fish start at the head of LGR pool
> 680 fish reach Lower Granite Dam
> 347 reach McNary Dam
> 216 reach John Day Dam
> 185 reach The Dalles Dam
> 141 reach Bonneville Dam
> 138 reach the Bonneville Tailrace

The survival rate associated with this operation is 13.8%. In this operation, the survival rate is higher than the survival rate of non-transported fish and lower than the combined survival rate associated with the transport operation described above. The estimated number of in-river migrants remaining in the river below Bonneville Dam is much higher (138 compared to 5) than under a transport operation.

<u>Fate of Juveniles Arriving at the Head of LGR Reservoir - Combining Transport and Non-transport Analyses</u>

Using the survival rate of in-river migrants calculated from an analysis without transportation (13.8%) and the number of in-river migrants that are likely to arrive below Bonneville Dam under a transport operation (5.2 fish), one can calculate that the number of fish initially arriving at Lower Granite pool that experience the calculated in-river survival rate is only about 38 fish, or about 4% of the population arriving at the head of Lower Granite reservoir (calculated as 5.2 survivors ÷ 0.138 survival rate = 37.7 initial juveniles).

This calculation suggests that the change in in-river survival that was estimated in the September 9th draft Opinion should have been weighted by a much lower percentage than 45-50%. However, if only 38 of 1000 fish at the head of LGR pool are affected by this in-river survival rate, the remainder of the 439 fish that die (or residualize) somewhere in the river under a transportation operation must also be addressed Additionally, there must be some evaluation of the effect of D for transported fish.

To address these issues, I evaluated the reference and proposed operations, including transportation, under a range of D values that is consistent with available empirical information. Williams *et al.* (2004) suggest that SR fall chinook "D" is highly uncertain, with a very approximate range from (0.67 * in-river survival from transport projects to BON) to (1.5 * in-river survival from transport projects to BON). To simplify the calculation of in-river survival, I assumed that all fish are transported from Lower Granite Dam. Because there are seven projects below LGR, and fewer dams below other collector projects, this approach gives a very conservative (low) estimate of in-river survival and, therefore, a conservative estimate of D. Results of the SIMPAS 2004 proposed operation analysis, which is approximately the same as current in-river operations, was evaluated to estimate the average in-river survival under a range of water year conditions (Table 1). The resulting in-river survival estimates were then multiplied by 0.67 and 1.5 to derive the range of D-values. The result was a mean range from D=0.18 to D=0.41. The lowest D estimated for an individual water year was 0.11, and the highest was 0.65.

<u>Comparison of Proposed and Reference Operations</u>

When the reference operation is compared to the proposed operation, the difference in the number of fish below Bonneville Dam is generally low. For example, Figure 2 compares survival estimates for the reference operation and the 2010 proposed operation under 1995 water conditions. The difference is approximately one fish per 1000 juveniles originally arriving at the head of Lower Granite Dam.

This information may be informative for comparison with life stages immediately below Bonneville Dam, because an offset in abundance would affect the same life stage and presumably result in a similar number of returning adults. However, in general it is necessary to compare changes in the relative survival rate, so that offsets can occur in different life stages with different base survival rates.

The survival rates for the combination of transported and non-transported fish in our example of the reference and 2010 proposed operation for the 1995 water year, given a range of D=0.18 to D=0.41, are:

<u>In-river</u> <u>Transport</u>
Reference Operation = (0.44 * 0.0117) + (0.56 * 0.98* "D") = 0.104 to 0.230

2010 Proposed Operation = (0.44 * 0.0095) + (0.56 * 0.98 * "D") = 0.103 to 0.229

A key assumption in this analysis is that D is equal in both the reference and proposed operations, for reasons described in the Opinion. The relative difference in survival between the two operations, given this range of likely D-values, is:

(0.103 - 0.104) ÷ 0.104 = -0.96% to
(0.229 - 0.230) ÷ 0.230 = -0.43%

In other words, for this example, consideration of a range of D-values results in estimation of a relative change in survival for the population as a whole, not just the in-river or transported components, of somewhere between one-half of one percent and one percent.

Table 2 and Figure 3 display estimates of the average (over all water years) relative differences in survival between the reference operation and proposed operations in 2004, 2010, and 2014, given a range of D estimates. Table 2 and Figure 4 display estimates of the absolute difference in survival rates for the same comparisons and D assumptions. Table 3 and Figure 5 display differences in abundance expected from the same comparisons and D assumptions. Information from these tables was incorporated into Section 6.0 of the final Opinion.

<u>Effect of Latent Mortality of In-river Migrants on Calculations</u>

I have ignored the possible effects of latent mortality of in-river migrants (μ_i , as described by Williams *et al.* 2004) in order to simplify the calculations and discussion to this point. Assuming that there is some latent mortality of in-river fish, which, like "D," is currently unknown, the survival rates in the reference and proposed operations in our example would be:

<u>In- River</u> <u>Transport</u>
Reference Operation = (0.44 * 0.0117 * [1- μ_i]) + (0.56 * 0.98* ["D"* (1- μ_i)])

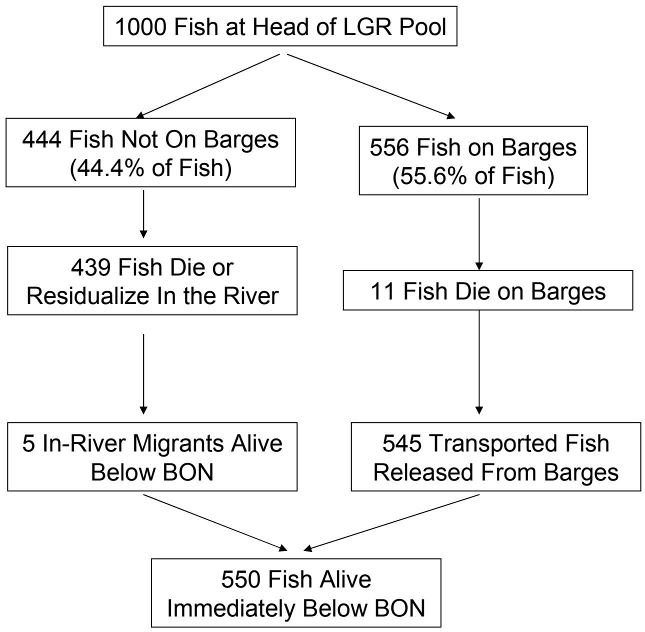
Proposed Operation = (0.44 * 0.0095 * [1- μ_i]) + (0.56 * 0.98* ["D"* (1- μ_i)])

If μ_i is equal in the proposed and reference operations, it will have no effect on the proportional difference in operations, as described above. However, this can have a significant effect on absolute survival rates, because it also influences transport survival. Williams *et al.* (2004) indicate that μ_i is likely to be greater than zero, but we have no basis for assigning a range of possible estimates of latent mortality of in-river migrants. If non-zero estimates were available, both in-river and transport survival would have to be adjusted, which would affect the absolute estimates of survival (but not the proportional differences in survival between operations). However, if μ_i differs between the two operations, it can have a large effect on the proportional difference.

Literature Cited

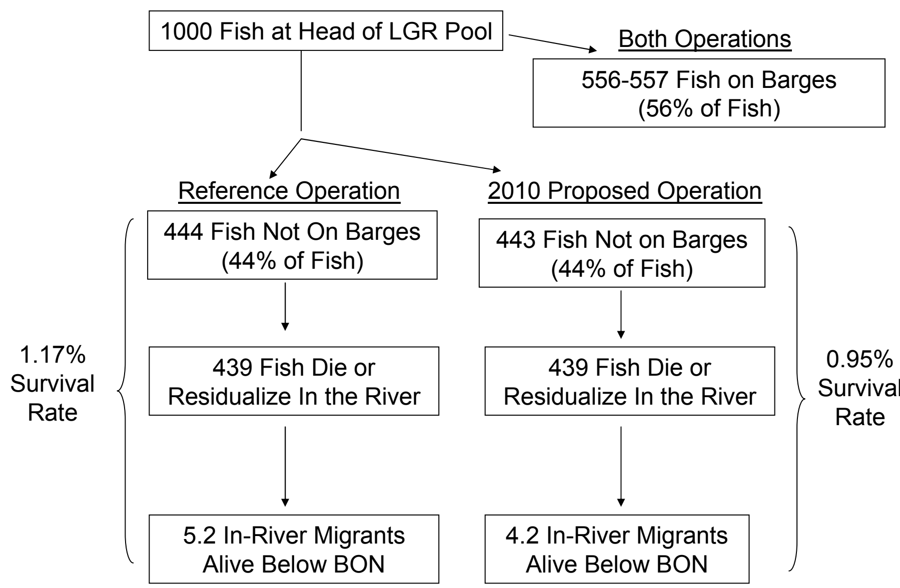
Williams, J. G., S. G. Smith, W. D. Muir, B. P. Sandford, S. Achord, R. McNatt, D. M. Marsh, R. W. Zabel, and M. D. Scheuerell. 2004. Effects of the Federal Columbia River Power System on salmon populations. NOAA Fisheries Technical Memorandum. Northwest Fisheries Science Center, Seattle, Washington. 152 p.

Figure 1. SIMPAS estimated fate of 1000 fish arriving at the head of Lower Granite pool, based on the 2010 proposed action under 1995 water conditions.



(Not considering D or latent mortality of in-river fish)

Figure 2. Comparison of in-river survival estimates for reference operation and 2010 proposed operation under 1995 water conditions.



Approximately 1 fish difference between operations.
(Not considering D or latent mortality of in-river fish)

Figure 3. Sensitivity of relative survival difference between the proposed and reference operations, given a range of potential D-values.

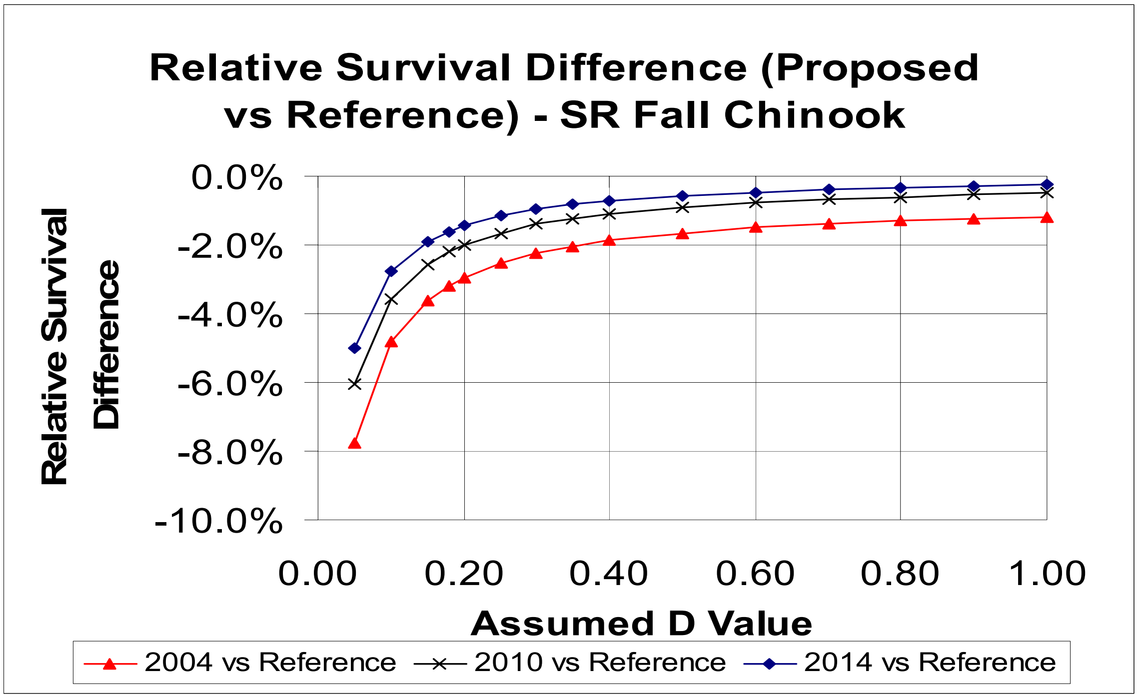


Figure 4. Sensitivity of relative survival difference between the proposed and reference operations, given a range of potential D-values.

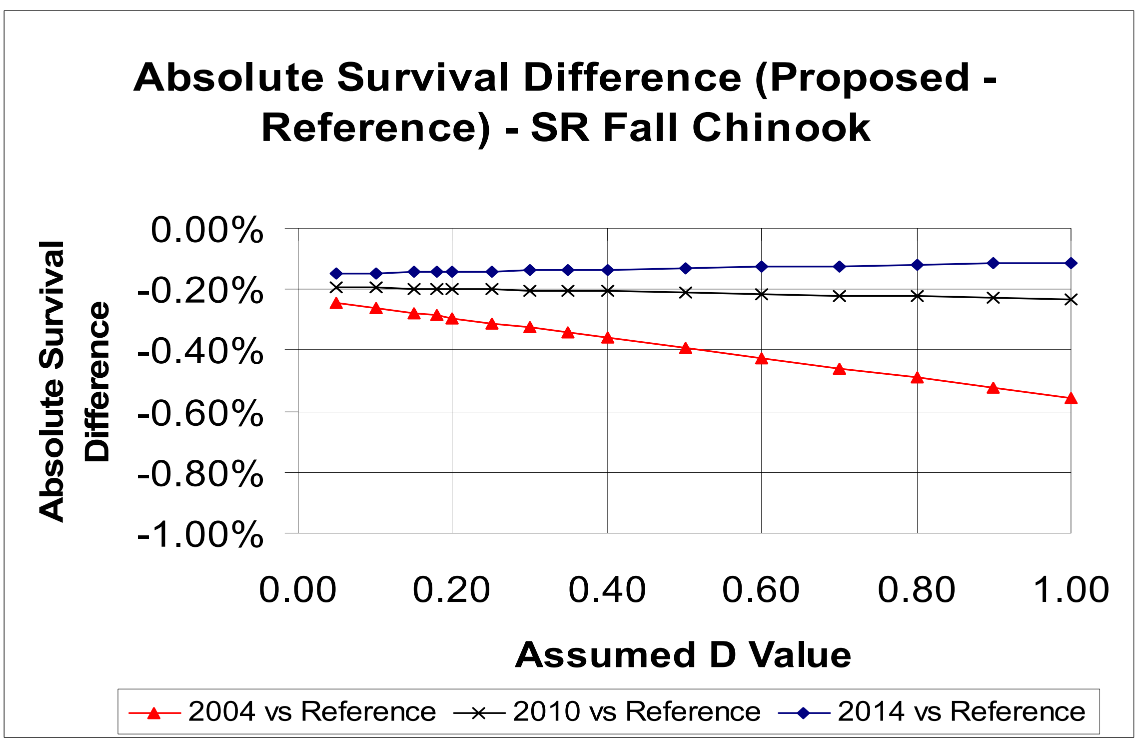


Figure 5. Sensitivity of absolute difference in number of juveniles below Bonneville Dam between the proposed and reference operations, given a range of potential D-values. Assumes 1000 juveniles initially arrive at Lower Granite reservoir.

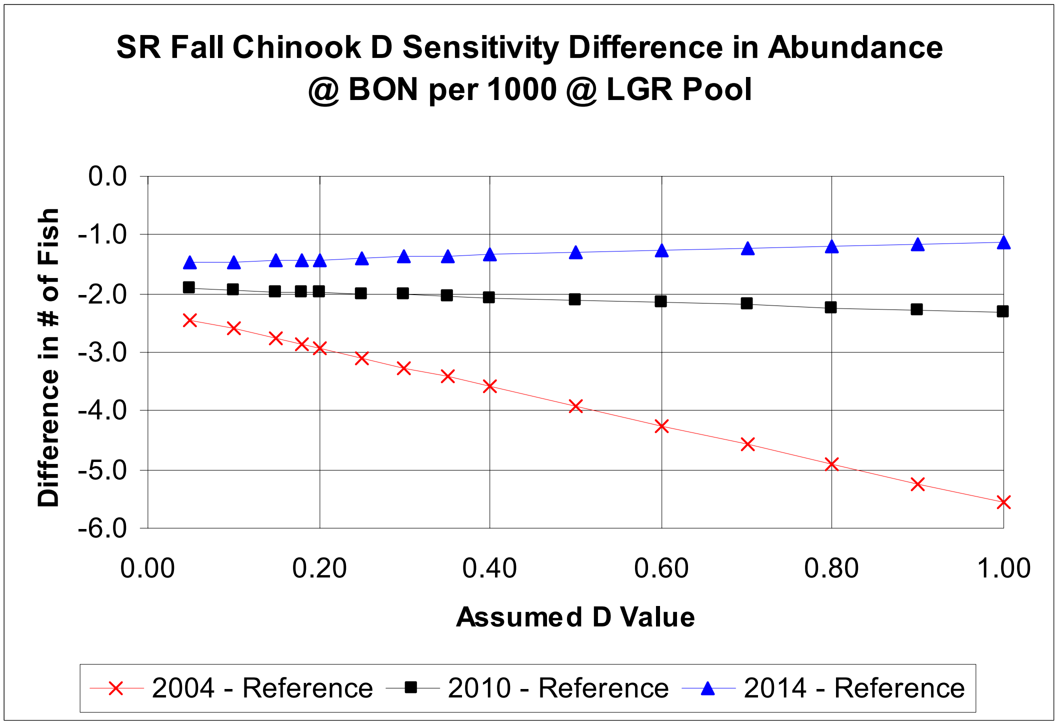


Table 1. Estimates of the likely range of D-values, given in-river survival from LGR tailrace to Bonneville Dam and the range of multipliers from Williams *et al.* (2004).

SIMPAS 2004 Operation (current condition - most likely to match T:I estimates that the 0.67-1.5 range is derived from)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	Mean
Total In-River Survival	0.1134	0.1822	0.2194	0.1274	0.1589	0.1292	0.0835		0.1220	0.1420
LGR survival	0.6780	0.5230	0.5060	0.5910	0.7390	0.5280	0.2530		0.5550	0.5466
Survival Below LGR	0.1673	0.3484	0.4336	0.2156	0.2150	0.2447	0.3300		0.2198	0.2718
D based on 0.67	0.11	0.23	0.29	0.14	0.14	0.16	0.22		0.15	0.18
D based on 1.5	0.25	0.52	0.65	0.32	0.32	0.37	0.50		0.33	0.41

Table 2. SR Fall Chinook

Combined In-River and Transport Survival and Abundance Differences, Given a Range of D Values

Assumed D	Absolute Difference In Survival Rate: 2004 - Reference	2010 - Reference	2014 - Reference	Relative Difference In Survival Rate: 2004 vs Reference	2010 vs Reference	2014 vs Reference
1.00	-0.0056	-0.0023	-0.0011	-1.2%	-0.5%	-0.2%
0.90	-0.0052	-0.0023	-0.0012	-1.2%	-0.5%	-0.3%
0.80	-0.0049	-0.0022	-0.0012	-1.3%	-0.6%	-0.3%
0.70	-0.0046	-0.0022	-0.0012	-1.4%	-0.7%	-0.4%
0.60	-0.0042	-0.0022	-0.0013	-1.5%	-0.8%	-0.5%
0.50	-0.0039	-0.0021	-0.0013	-1.7%	-0.9%	-0.6%
0.40	-0.0036	-0.0021	-0.0013	-1.9%	-1.1%	-0.7%
0.35	-0.0034	-0.0020	-0.0014	-2.0%	-1.2%	-0.8%
0.30	-0.0033	-0.0020	-0.0014	-2.3%	-1.4%	-1.0%
0.25	-0.0031	-0.0020	-0.0014	-2.5%	-1.6%	-1.2%
0.20	-0.0029	-0.0020	-0.0014	-3.0%	-2.0%	-1.5%
0.18	-0.0029	-0.0020	-0.0014	-3.2%	-2.2%	-1.6%
0.15	-0.0028	-0.0020	-0.0014	-3.6%	-2.6%	-1.9%
0.10	-0.0026	-0.0019	-0.0015	-4.8%	-3.6%	-2.8%
0.05	-0.0024	-0.0019	-0.0015	-7.8%	-6.0%	-5.0%

Table 3. SR Fall Chinook

Combined In-River and Transport Survival and Abundance Differences, Given a Range of D Values

	Number of Fish Per 1000 @ LGR Pool			Number of Fish Per 2 Million @ LGR Pool		
Assumed D	2004 - Reference	2010 - Reference	2014 - Reference	2004 - Reference	2010 - Reference	2014 - Reference
1.00	-5.6	-2.3	-1.1	-11,125	-4,650	-2,250
0.90	-5.2	-2.3	-1.2	-10,468	-4,565	-2,323
0.80	-4.9	-2.2	-1.2	-9,810	-4,480	-2,395
0.70	-4.6	-2.2	-1.2	-9,153	-4,395	-2,467
0.60	-4.2	-2.2	-1.3	-8,495	-4,310	-2,540
0.50	-3.9	-2.1	-1.3	-7,838	-4,225	-2,612
0.40	-3.6	-2.1	-1.3	-7,180	-4,140	-2,685
0.35	-3.4	-2.0	-1.4	-6,851	-4,098	-2,721
0.30	-3.3	-2.0	-1.4	-6,523	-4,055	-2,758
0.25	-3.1	-2.0	-1.4	-6,194	-4,013	-2,794
0.20	-2.9	-2.0	-1.4	-5,865	-3,970	-2,830
0.18	-2.9	-2.0	-1.4	-5,734	-3,953	-2,845
0.15	-2.8	-2.0	-1.4	-5,536	-3,928	-2,866
0.10	-2.6	-1.9	-1.5	-5,208	-3,885	-2,903
0.05	-2.4	-1.9	-1.5	-4,879	-3,843	-2,939